PUERTO RICO AND U.S. VIRGIN ISLANDS PRECIPITATION FREQUENCY PROJECT

Update of *Technical Paper No. 42* and *Technical Paper No. 53*

Twenty-fourth Progress Report
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Hydrometeorological Design Studies Center
Hydrology Laboratory

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DISCLAIMER

The data and information presented in this report are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk

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Update of *Technical Paper No. 42* and *Technical Paper No. 53*

1. Introduction

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development of NOAA's National Weather Service has updated its precipitation frequency estimates for Puerto Rico and the U.S. Virgin Islands. Previous precipitation frequency estimates for the area are contained in *Technical Paper No. 42* "Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands" (U.S. Weather Bureau, 1961) and *Technical Paper No. 53* "Two- to ten-day rainfall for return periods of 2 to 100 years in Puerto Rico and Virgin Islands" (Miller, 1965). The new project included collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The project determined annual precipitation frequencies for durations from 5 minutes to 60 days, for average recurrence intervals from 1 to 1,000 years. The project reviewed and processed all available rainfall data for the Puerto Rico and Virgin Island project area and used accepted statistical methods. The project results were published as Volume 3 of NOAA Atlas 14 on the Internet (http://www.nws.noaa.gov/ohd/hdsc) with the ability to download digital files.

The project area covers Puerto Rico and the U.S. Virgin Islands of St. Thomas, St. John and St. Croix. The project area is divided into 9 regional groups for long duration (24-hour through 60-day) analyses (Figure 1) and 4 regional groups for short duration (60-minute through 12-hour) analyses (Figure 2).

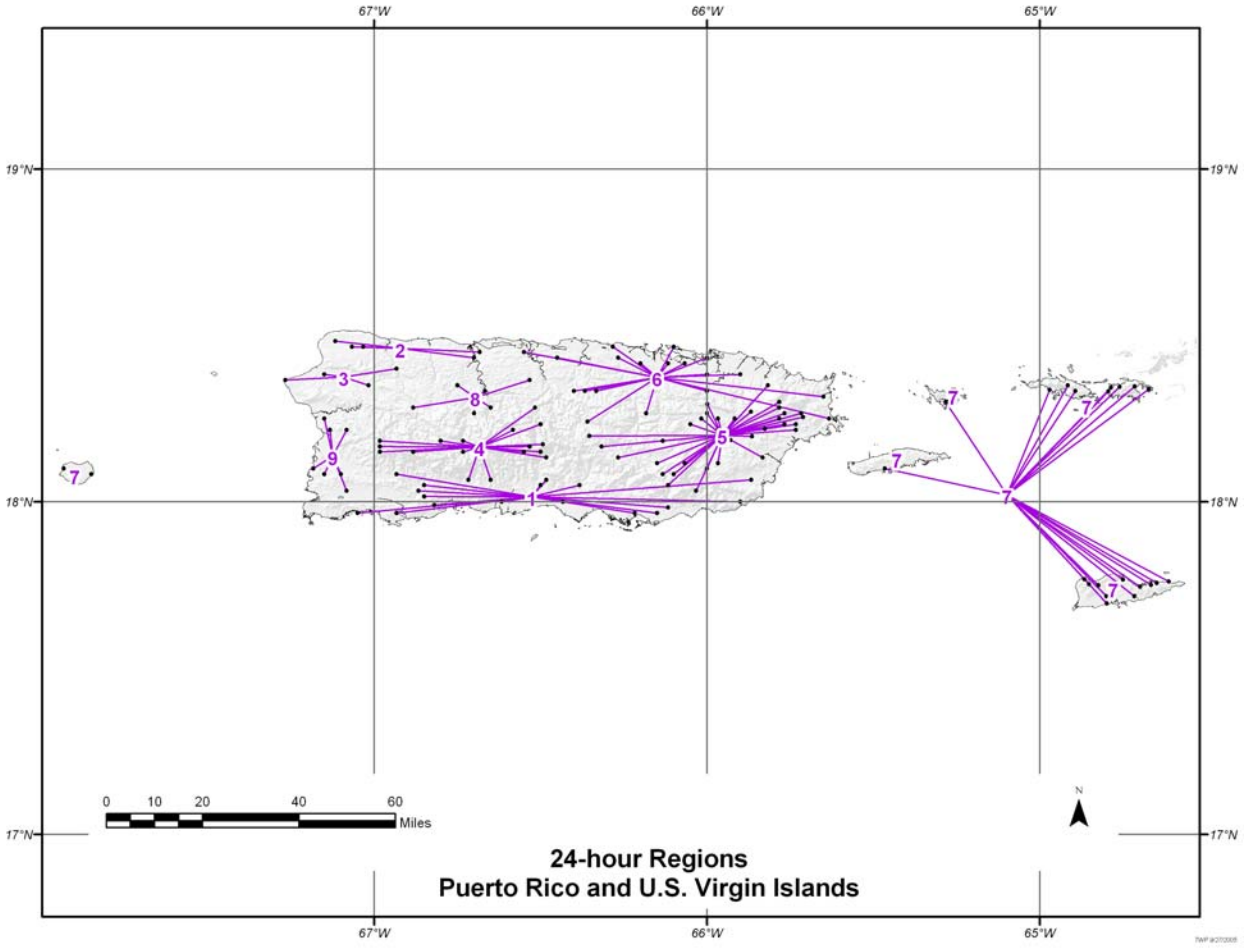

Figure 1. Puerto Rico Precipitation Frequency project area and 9 regional groups based on 24-hour data.

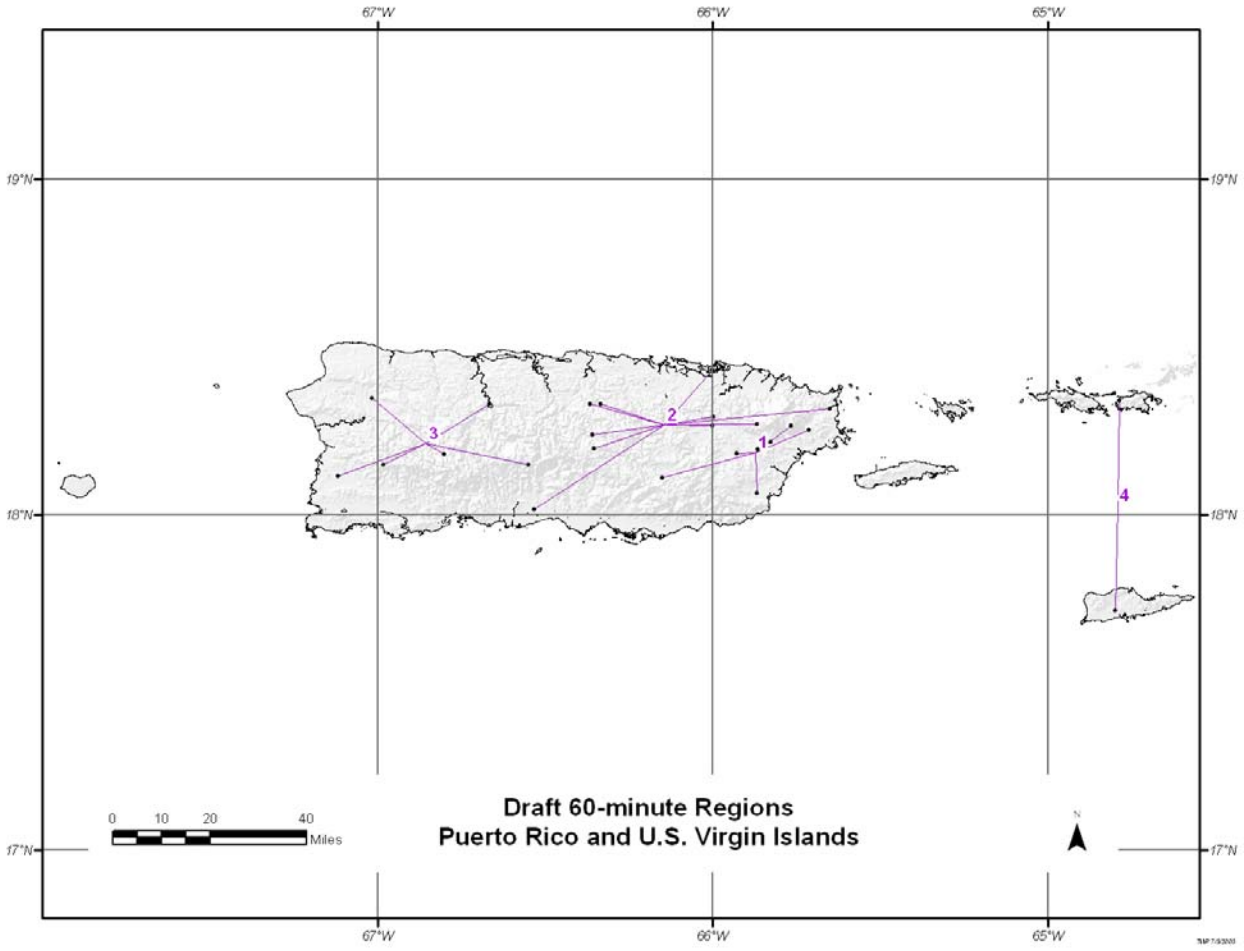

Figure 2. Puerto Rico Precipitation Frequency project area and 4 regional groups based on 60-minute data.

2. Highlights

On June 28th, 2006 HDSC published NOAA Atlas 14 Volume 3, Precipitation Frequency estimates for Puerto Rico and the U.S. Virgin Islands. Accompanying final documentation will be published during the next quarter. Additional information is provided in Section 3.1, Publication.

Prior to publication, using feedback provided by peer reviewers and critical internal reviews, HDSC worked with Oregon State University's PRISM Group to develop final grids of mean annual precipitation for all durations. To achieve a higher spatial density for spatially interpolating hourly estimates, ≤ 12-hour data were objectively developed for daily-only (≥ 24 hours only) stations. This resulted in grids that were consistent across durations and resolved several important spatial features noted by peer reviewers or that would have otherwise gone undetected. Additional information is provided in Section 3.2, Spatial Interpolation.

HDSC continuously monitors the hits, integrity and performance of the Precipitation Frequency Data Server (PFDS), the on-line portal for all NOAA Atlas 14 deliverables and information. Additional information is provided in Section 3.3, PFDS.

Work continues on the development of geographically fixed Areal Reduction Factors (ARFs) for area sizes of 10 to 500 square miles and durations of 30-minutes to 48-hours for the United States. Additional information is provided in Section 3.4, Areal Reduction Factors.

On June 19th, 2006 HDSC released NOAA Atlas 14 Volume 1 Version 4, Precipitation Frequency Estimates for the Semiarid Southwest United States including Arizona, Southeast California, Nevada, New Mexico, and Utah. This is an update to Volume 1 Version 3. Additional information is provided in Section 4.3, Update of NOAA Atlas 14 Volumes 1 and 2.

3. Progress in this Reporting Period

3.1 Publication

On June 28th, 2006 HDSC published NOAA Atlas 14 Volume 3, Precipitation Frequency estimates for Puerto Rico and the U.S. Virgin Islands. The estimates are available as a web based publication through the Precipitation Frequency Data Server (PFDS) on the HDSC web site at: http://hdsc.nws.noaa.gov/hdsc/pfds/index.html.

Final documentation of the entire project to accompany the estimates will be published during the next quarter.

3.2 Spatial Interpolation

Prior to publication, using feedback provided by peer reviewers and critical internal reviews, HDSC worked with Oregon State University's PRISM Group (formerly the Spatial Climate Analysis Service) to develop final grids of mean annual precipitation for all durations (60-minute through 60-day).

Based in part on peer review feedback, it was clear that the lack of station data available for durations of 12 hours or less was insufficient for the interpolation scheme to resolve the spatial patterns. In an effort to bring the ≤ 12-hour station density up to that for ≥ 24 hours, ≤ 12-hour data were objectively developed for daily-only stations (≥ 24 hours only) during the PRISM modeling configuration. The procedure was as follows:

(1) Convert available ≤ 12-hour station values to an index flood/24-hr index flood ratio (termed R24) (where "index flood" values are mean annual maximums);
(2) Generate R24 grids by interpolating R24 values for each ≤ 12-hour duration (60-minutes, and 2-, 3-, 6-, and 12-hours) from (1) using an inverse distance weighting algorithm;
(3) Extract R24 at the location of each daily-only station location from the R24 grids from (2);
(4) Compute ≤ 12-hour values by multiplying the R24 values from (3) by the 24-hour value at each daily-only station;
(5) Append the estimated stations from (4) to the ≤ 12-hour station list to generate a station list that matches the density of that for ≥ 24 hours; and
(6) Interpolate index flood values for ≤ 12-hour durations with PRISM, using mean annual precipitation as the predictor grid (the same way as was done for ≥ 24-hour durations).

This procedure resulted in grids of mean annual maximums that were consistent across durations, particularly between 12-hour and 24-hour, and resolved several important spatial features noted by peer reviewers or that would have otherwise gone undetected. Furthermore, the procedure is consistent with methods (see Volume 2 final

documentation at http://hdsc.nws.noaa.gov/hdsc/pfds/docs/NA14Vol2_4spatial.pdf) used to objectively develop ≤ 12-hour precipitation frequency estimates at daily-only stations. As a result, the maps/grids now contain a greater level of spatial detail than those evaluated during the peer review, but the general patterns remained the same.

On May 12th, 2006 the Oregon State University's PRISM Group delivered the final high-resolution (3-second) interpolated grids of mean annual precipitation to HDSC. Shortly thereafter, the PRISM Group delivered their final report, which will be included in the final documentation.

Based upon the PRISM grids of mean annual precipitation, HDSC derived the entire suite of precipitation frequency grids using the Cascade Residual Add-back (CRAB) procedure. (For a description of the CRAB procedure, please see Volume 2 final documentation at http://hdsc.nws.noaa.gov/hdsc/pfds/docs/NA14Vol2_4spatial.pdf.) A subset of the grids was converted into maps, which served as the basis for internal review. The internal review focused on several issues raised during the peer review and changes as a result of enhancements to the PRISM modeling configuration (i.e., the estimated ≤ 12-hour station data). After the internal review, the final precipitation frequency grids were created and readied for publication, which took place June 28th, 2006. Additionally, 32 of the grids and associated shapefiles of the contours were used to create color, cartographic-quality maps that are available via the PFDS. Table 1 lists the available cartographic maps.

Table 1. 32 key cartographic maps that were released with NOAA Atlas 14 Volume 3.

Average Recurrence Interval	Duration
1-year	60-minute
2-year	60-minute
5-year	60-minute
10-year	60-minute
25-year	60-minute
50-year	60-minute
100-year	60-minute
1,000-year	60-minute
1-year	6-hour
2-year	6-hour
5-year	6-hour
10-year	6-hour
25-year	6-hour
50-year	6-hour
100-year	6-hour
1,000-year	6-hour
1-year	24-hour
2-year	24-hour
5-year	24-hour
10-year	24-hour

Average Recurrence Interval	Duration
25-year	24-hour
50-year	24-hour
100-year	24-hour
1,000-year	24-hour
2-year	48-hour
2-year	10-day
2-year	30-day
2-year	60-day
100-year	48-hour
100-year	10-day
100-year	30-day
100-year	60-day

Prior to the release of the final grids, several of the maps (100-year 1-hour and 100-year 24-hour) in Technical Paper No. 42 "Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands" (U.S. Weather Bureau, 1961) were digitized, converted into grids and used to make objective comparisons. In general, NOAA Atlas 14 has higher estimates at 100-year 24-hour, but lower at 100-year 1-hour. These maps and a discussion will be included in the final documentation.

3.3 PFDS

The Precipitation Frequency Data Server (PFDS), the on-line portal for all NOAA Atlas 14 deliverables and information, did not undergo any significant changes this quarter.

HDSC continuously monitors the hits, integrity and performance of the PFDS, which continues to receive a steady number of hits per month. The graph (Figure 3) below summarizes the number of individual data inquires made since June 2004, while the map (Figure 4) indicates the locations of inquires during the past quarter.

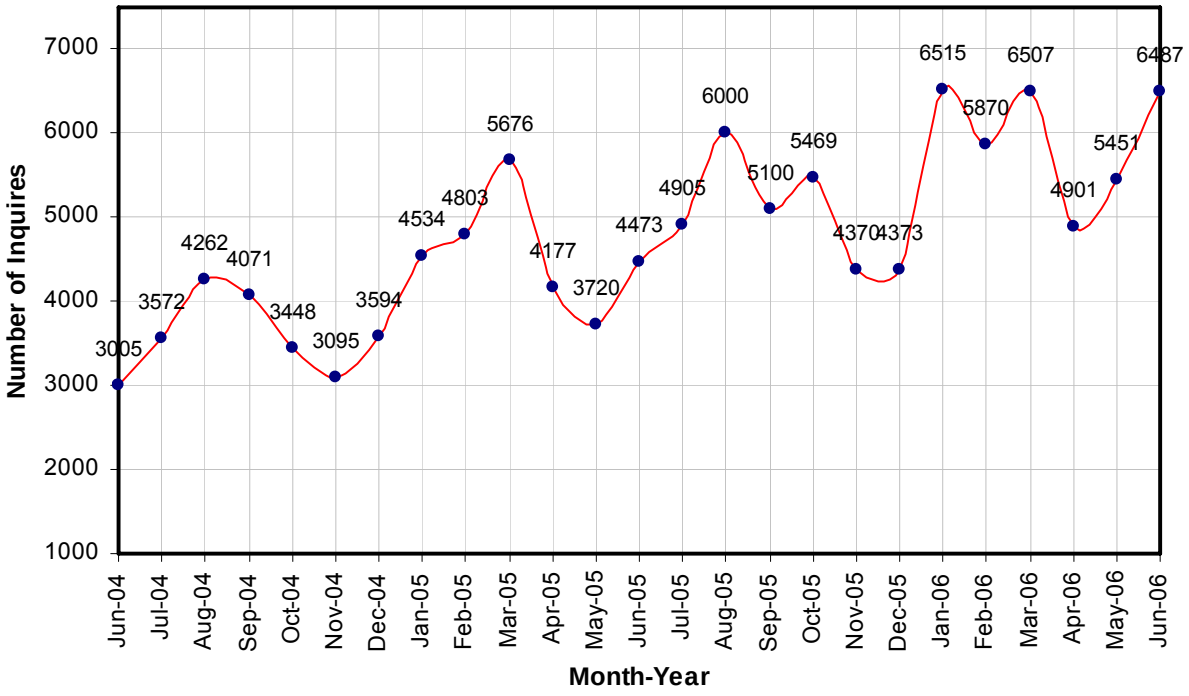

Figure 3: Number of individual PFDS data inquires per month.

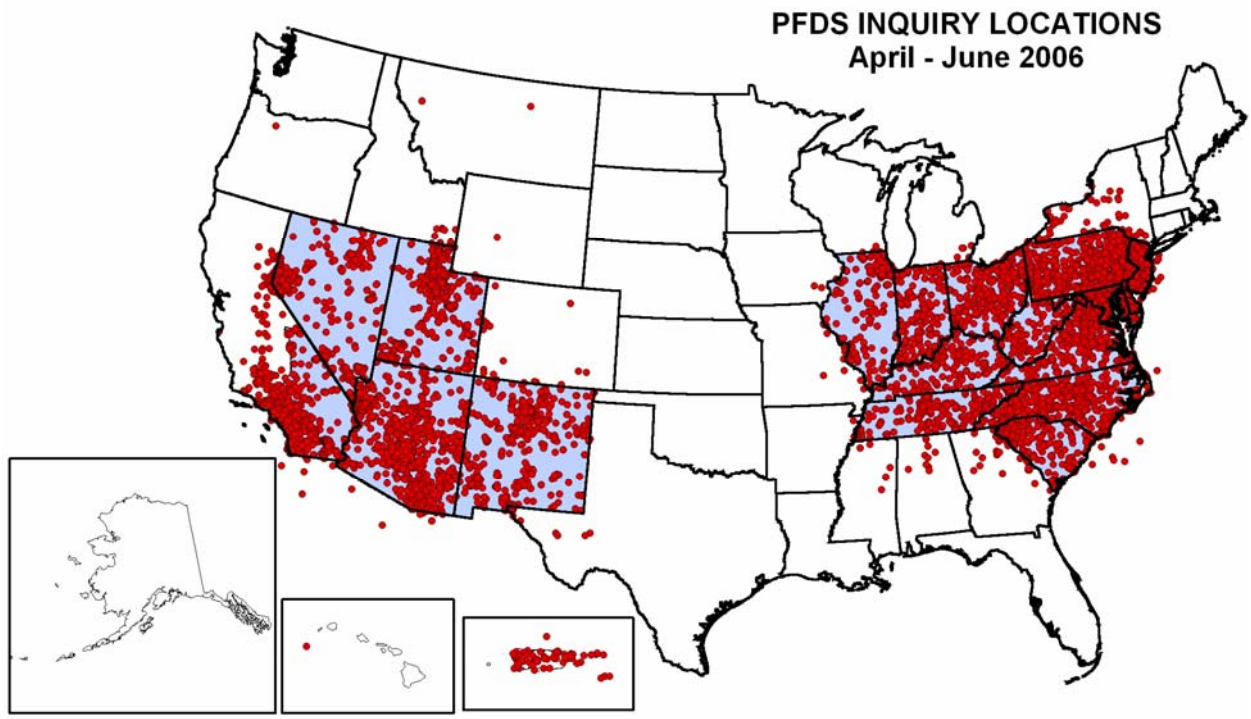

Figure 4: Map of 16,839 PFDS data inquiry locations during the period April-June 2006.

3.4 Areal Reduction Factors

Work continues in the development of geographically fixed Areal Reduction Factors (ARFs) for area sizes of 10 to 500 square miles and durations of 30-minutes to 48-hours for the United States. The results of this supplementary study will be applicable to all volumes of NOAA Atlas 14.

Although ARF software development has been slow, it continues to move forward. The continuing goal is to develop ARF software based on the NOAA Technical Report NWS 24 (Myers, V.A. and R.M. Zehr, 1980) methodology and obtain the same results published in TR-24 for the Chicago rain gauge network. The ARF computations are a function of six variables that vary in time and space. Fitting functions (curves) to these six variables so that the results are equal to those in TR-24 has been difficult.

Figure 5 shows the locations of all used, not used and considered rain gauge networks. Table 2 provides additional details of the preliminary study areas. After an exhaustive search for quality rain gauge networks that meet certain criteria (10+ years of concurrent hourly precipitation data at 10+ gauges over an area of ~100 to ~500 square miles), HDSC is no longer actively seeking additional networks unless user provided. Networks in Alaska, Puerto Rico and Hawaii were investigated but found insufficient.

Figure 5. Map of ARF study areas.

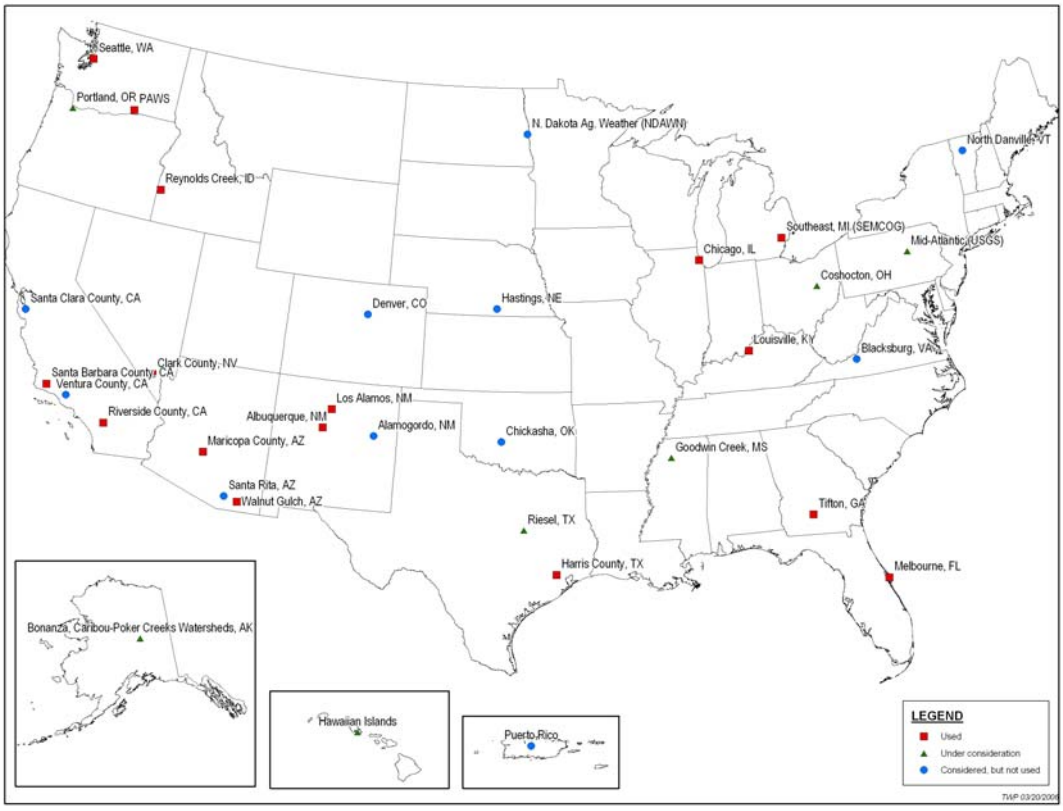

Table 2. Preliminary ARF study areas.

Study area location	Included	Date range	~Size (sq-mi)	Stations	Lat	Lon	Elev. (ft)
Albuquerque, NM	Yes	1978-1992	400	13	35.161	-106.566	5311
Chicago, IL	Yes	1949-1980	n/a	18	41.830	-87.692	618
Clark County, NV	Yes	1990-2004	n/a	48	36.290	-114.978	940
Los Alamos, NM	Yes	1990-2005	150	9	35.858	-106.282	7011
Maricopa county, AZ	Yes	1980-2001	n/a	31	33.789	-112.303	2572
Reynolds Creek, ID	Yes	1962-1996	n/a	44	43.169	-116.769	5342
Riverside county, CA	Yes	1961-2001	n/a	45	33.793	-116.995	1987
Santa Barbara, CA	Yes	1968-2003	n/a	38	34.590	-119.957	1203
Seattle, WA	Yes	1978-2003	216	23	47.553	-122.333	152
South-central Washington state (PAWS)	Yes	1989-2005	700	15	46.071	-119.306	765
Southeast Michigan (SEMCOG)	Yes	1988-2002	n/a	50	42.518	-83.286	730
Melbourne, FL	Yes	1997-2005	450	35	28.545	-80.634	0
Harris County, TX	Yes	1997-2005	3800	165	29.779	-95.405	n/a
Walnut Gulch, AZ	Yes	1954-1996	n/a	107	31.728	-110.024	4656
Chickasha (Micronet), OK	Maybe	1994-2005	1130	44	34.885	-98.075	398
Coshocton, OH	Maybe	1940-2001	n/a	22	40.435	-81.799	1044
Goodwin, MS	Maybe	1981-1996	n/a	32	34.232	-89.914	333
Jefferson County, KY	Yes	1990-2006	n/a	18	38.190	-85.670	n/a
Portland, OR	Maybe	1976-2005	200	45	45.537	-122.662	n/a
Tifton, GA	Maybe	1968-1981	n/a	55	31.439	-83.590	n/a
Ventura, CA	Maybe	n/a	n/a	134	34.370	-119.067	n/a
Bonanza, Caribou-Poker Creeks Watershed(s), AK	No	n/a	50	n/a	64.750	-148.230	1641
Puerto Rico (eastern)	No	1973-2003	500	10-18	18.260	-65.910	800
Hawaii	No	~1948-2005	n/a	n/a	n/a	n/a	n/a
Alamogordo Creek, NM	No	1955-1962	67	64	34.920	-104.143	4898
Blacksburg, VA	No	n/a	n/a	<10	37.250	-80.417	n/a
Denver, CO	No	n/a	n/a	n/a	39.750	-105.000	n/a
Ft. Collins, CO	No	1999-2005	12		40.567	-105.093	5099
Riesel, TX	No	n/a	10	39	31.482	-96.880	544
Hastings, NE	No	1938-1967	n/a	19	40.255	-98.376	n/a
North Danville, VT	No	1958-1975	n/a	27	49.678	-74.724	2118

4. Issues

4.1 New Employee

Daniel Brewer, a Science Applications International Corporation (SAIC) contractor, joined HDSC on April 10th, 2006 on a temporary basis during the absence of Debbie Martin on maternity leave. Dan has a degree in Meteorology from Millersville University in Millersville, PA.

4.2 California Precipitation Frequency Project

The state of California and others have committed to funding a project to update the precipitation frequency estimates for the remaining portion of California. Agencies involved include CA Department of Transportation, CA Department of Water Resources, NOAA Coastal Storms Program, and U.S. Army Corps of Engineers.

HDSC is in the process of formalizing an agreement with the California Department of Water Resources for the work. HDSC will update precipitation frequency estimates for the remainder of California not covered by NOAA Atlas 14 Volume 1. By the end of September 2006, HDSC will obtain all relevant NCDC rain gauge data. In addition, HDSC will begin to identify other non-NCDC data, such as ALERT data for possible inclusion in the project.

4.3 Update of NOAA Atlas 14 Volumes 1 and 2

On June 19th, 2006 HDSC released NOAA Atlas 14 Volume 1 Version 4, an update to Version 3. Volume 1 contains precipitation frequency estimates for the Semiarid Southwest United states including Arizona, Southeast California, Nevada, New Mexico, and Utah.

The Version 4 update represents an enhanced product that has added estimates for the 1-year average recurrence interval (ARI) and has extended the domain to include the entire Lake Tahoe basin. In addition, it incorporates some enhanced algorithms based on lessons learned in creating the newest volume, Volume 3 (Puerto Rico and the U.S. Virgin Islands). Each of the additions and enhancements were objectively justified and based on sound science. The enhancements include improved spatial interpolation when using the inverse-distance-weighting function, improved consistency adjustments for co-located daily and hourly stations and for hourly-only stations, and an improvement to the 24-hour confidence limits. An Addendum is available to provide additional details. It is available on our web site:
http://hdsc.nws.noaa.gov/hdsc/pfds/docs/NOAA_Atlas_14_Volume1_Version4_Addendum.pdf
Final associated documentation will be updated accordingly and released in the next quarter.

NOAA Atlas 14 Volume 2, precipitation frequency estimates for the Ohio River Basin and surrounding states will be updated during the next quarter with the same additions and enhancements.

5. Projected Schedule and Remaining Tasks

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks to be worked on are also included in this section.

Web Publication of Final Documentation [September 2006]
Spatial Relations (Areal Reduction Factors) [October 2006]

5.1 Web Publication of Final Documentation

Final documentation will be published on the web via the PFDS during the next quarter.

5.2 Areal Reduction Factors (ARF)

Computations for the ARF curves will be completed for 14 areas. The resulting curves will be tested for differences to determine if a single set of ARF curves is applicable to the entire U.S. or whether curves vary by region.

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